Earth's Energy Budget: A Story

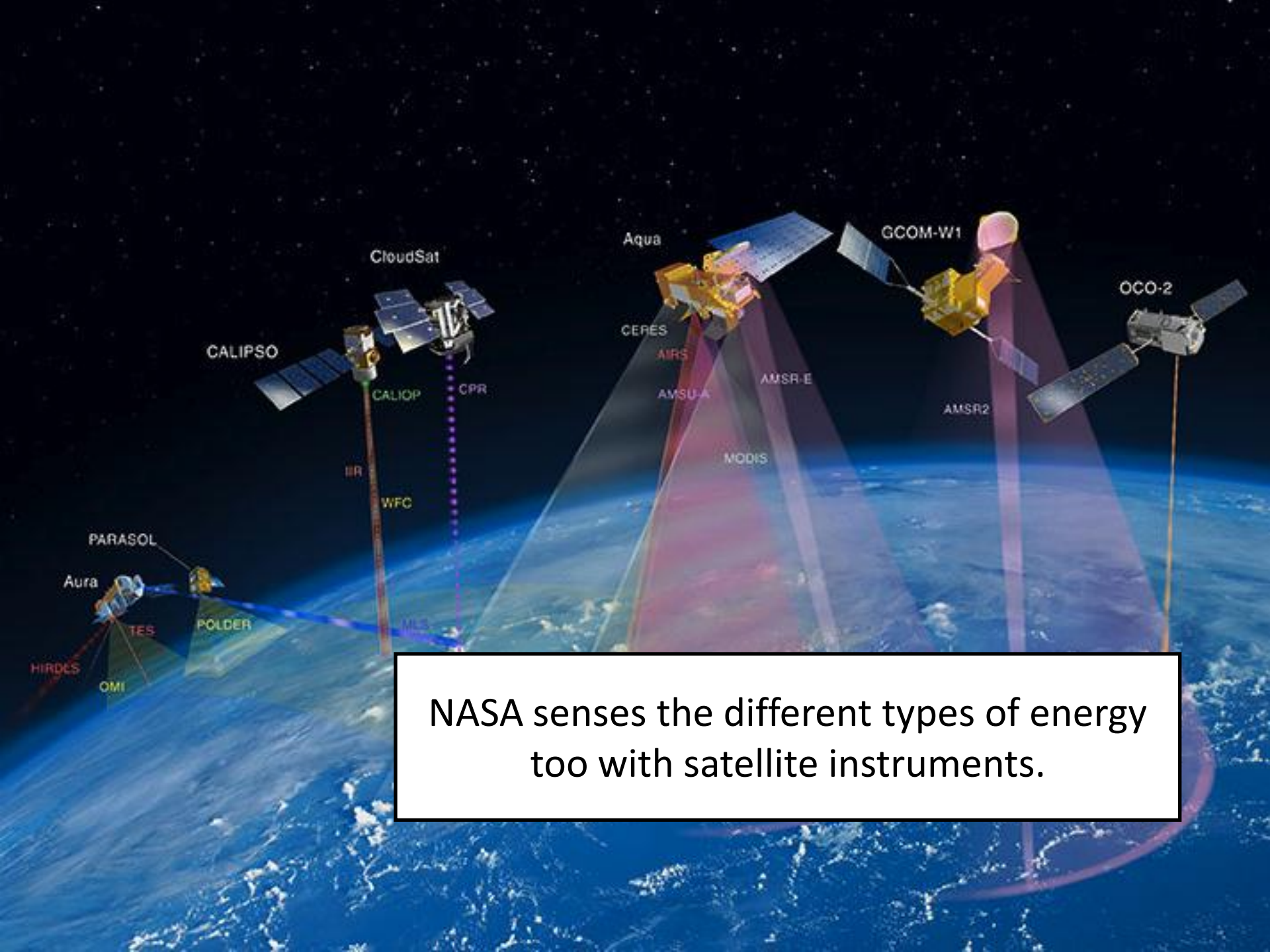
NASA Langley Research Center

2013


Most of the energy on Earth comes to us from the Sun.
Did you know?: The amount of sunlight that reaches the Earth is equal to approximately 6 60w light bulbs for every square meter of the surface.

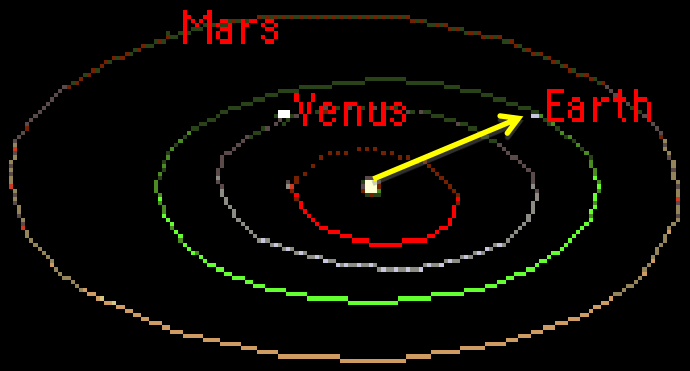
We can sense that energy in different ways. We see the things around us because of visible light…


… And we feel the heat from a campfire, which is infrared energy.



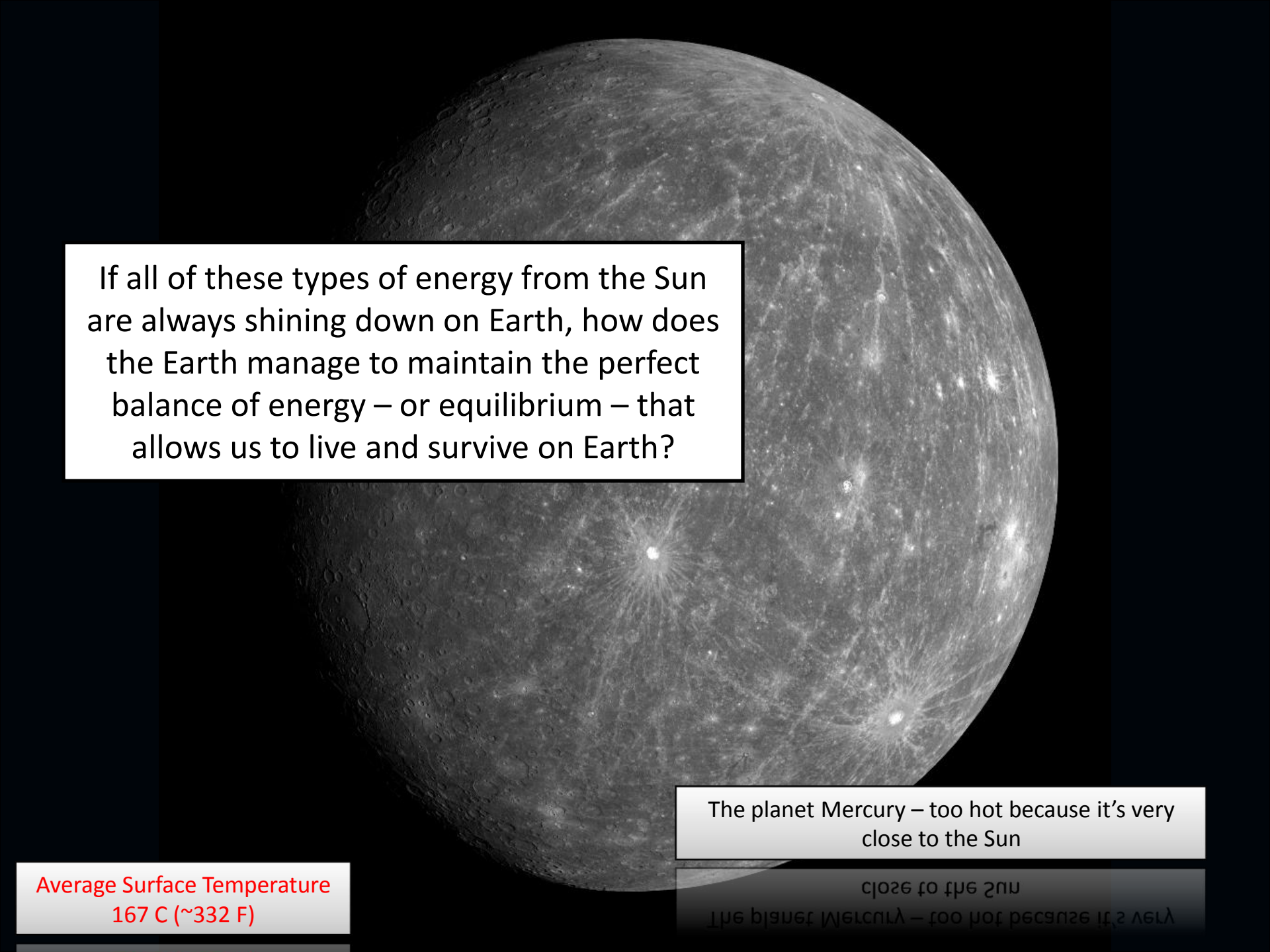
NASA senses the different types of energy too with satellite instruments.

If all of these types of energy from the Sun are always shining down on Earth, how does the Earth manage to maintain the perfect balance of energy – or equilibrium – that allows us to live and survive on Earth?



The Sun – hot though it is - is a tiny part of Earth's environment. The rest is cold, dark space.

If all of these types of energy from the Sun are always shining down on Earth, how does the Earth manage to maintain the perfect balance of energy – or equilibrium – that allows us to live and survive on Earth?



The planet Mercury – too hot because it's very close to the Sun

Average Surface Temperature
167 C (~332 F)

If all of these types of energy from the Sun are always shining down on Earth, how does the Earth manage to maintain the perfect balance of energy – or equilibrium – that allows us to live and survive on Earth?

The planet Mars – “too cold” because it is farther from the Sun and has a very thin atmosphere.

Average Surface Temperature - 65 C (~-85 F)

If all of these types of energy from the Sun are always shining down on Earth, how does the Earth manage to maintain the perfect balance of energy – or equilibrium – that allows us to live and survive on Earth?

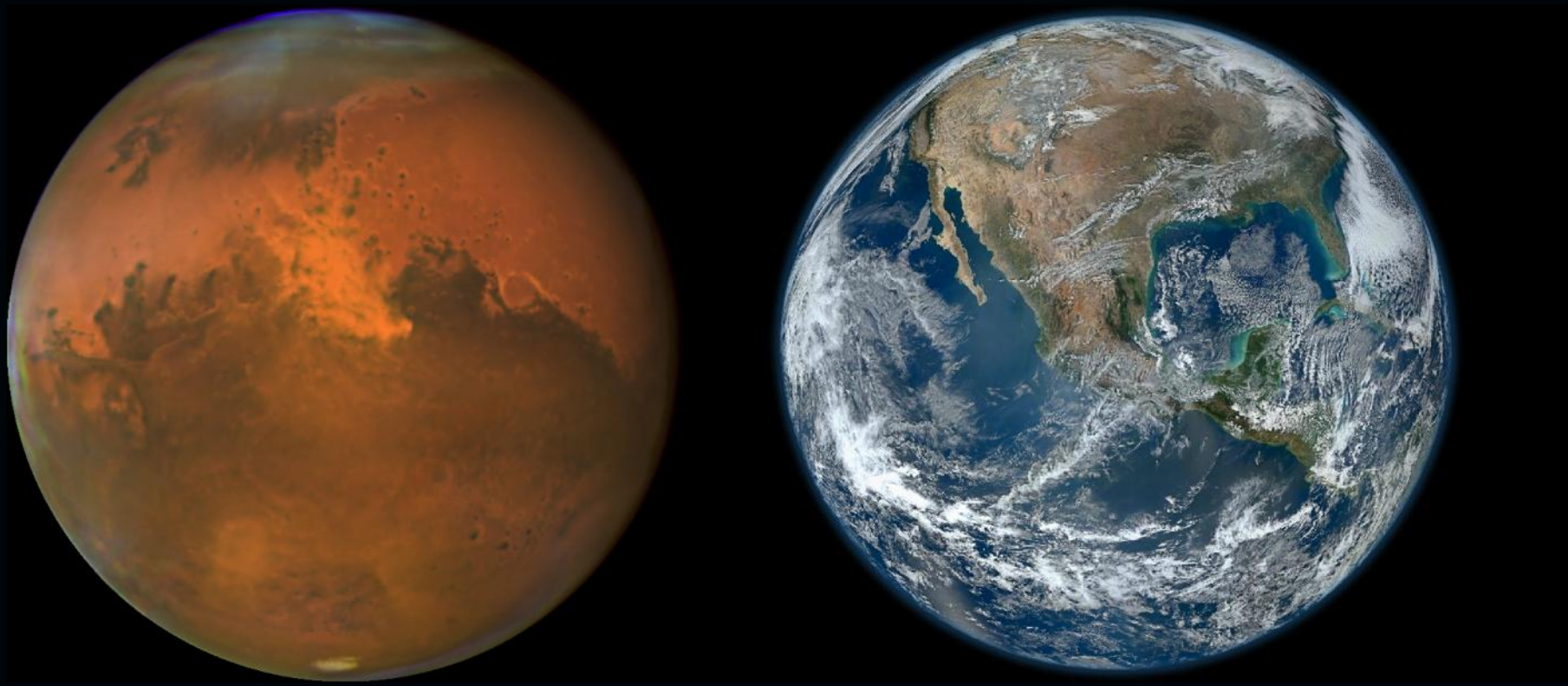
3rd rock from the Sun. Still too cold for life.

Average Surface Temperature - 18 C (~0 F)

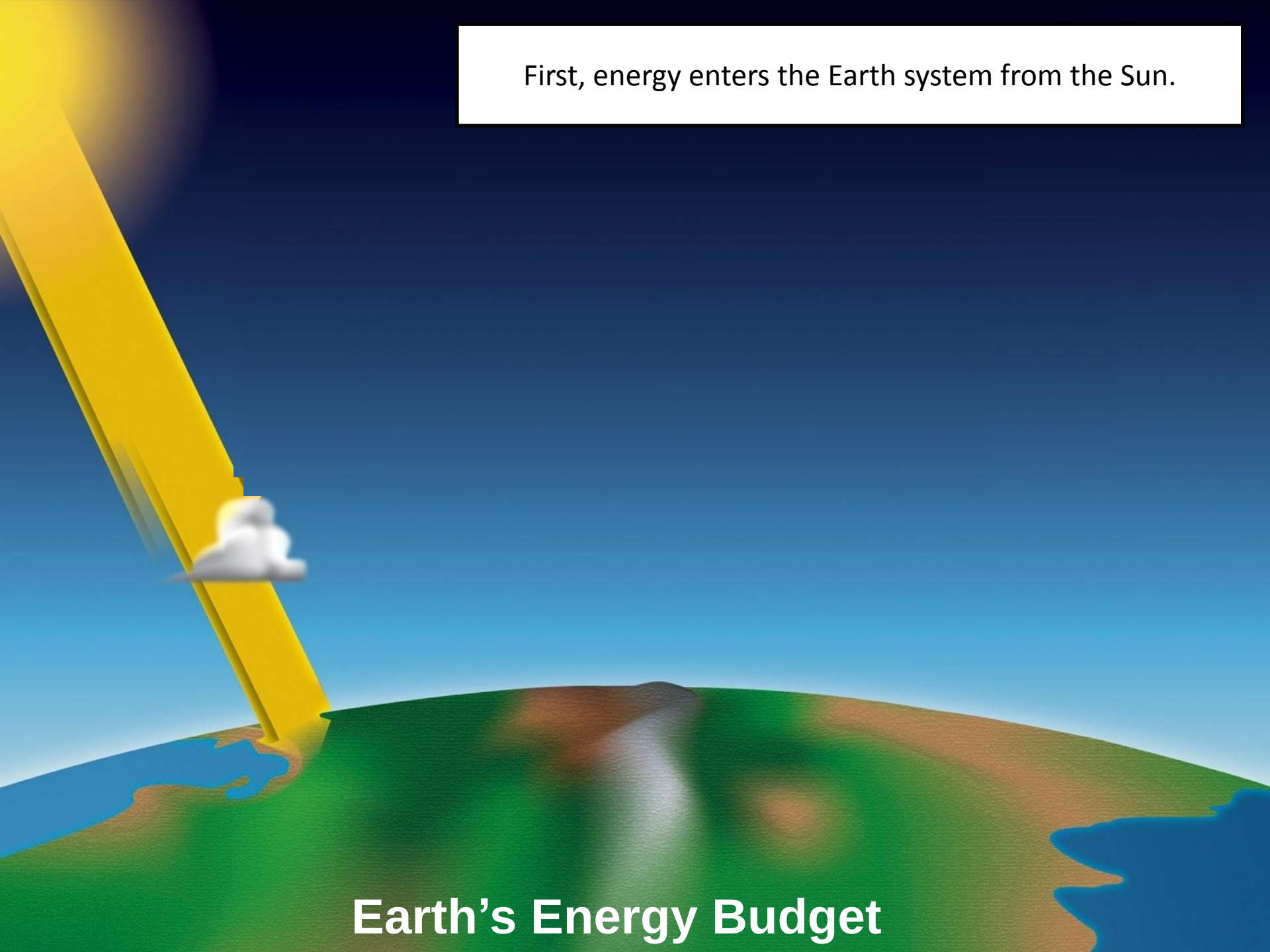
If all of these types of energy from the Sun are always shining down on Earth, how does the Earth manage to maintain the perfect balance of energy – or equilibrium – that allows us to live and survive on Earth?

The planet Earth with its atmosphere – just the right balance for life to survive and thrive.

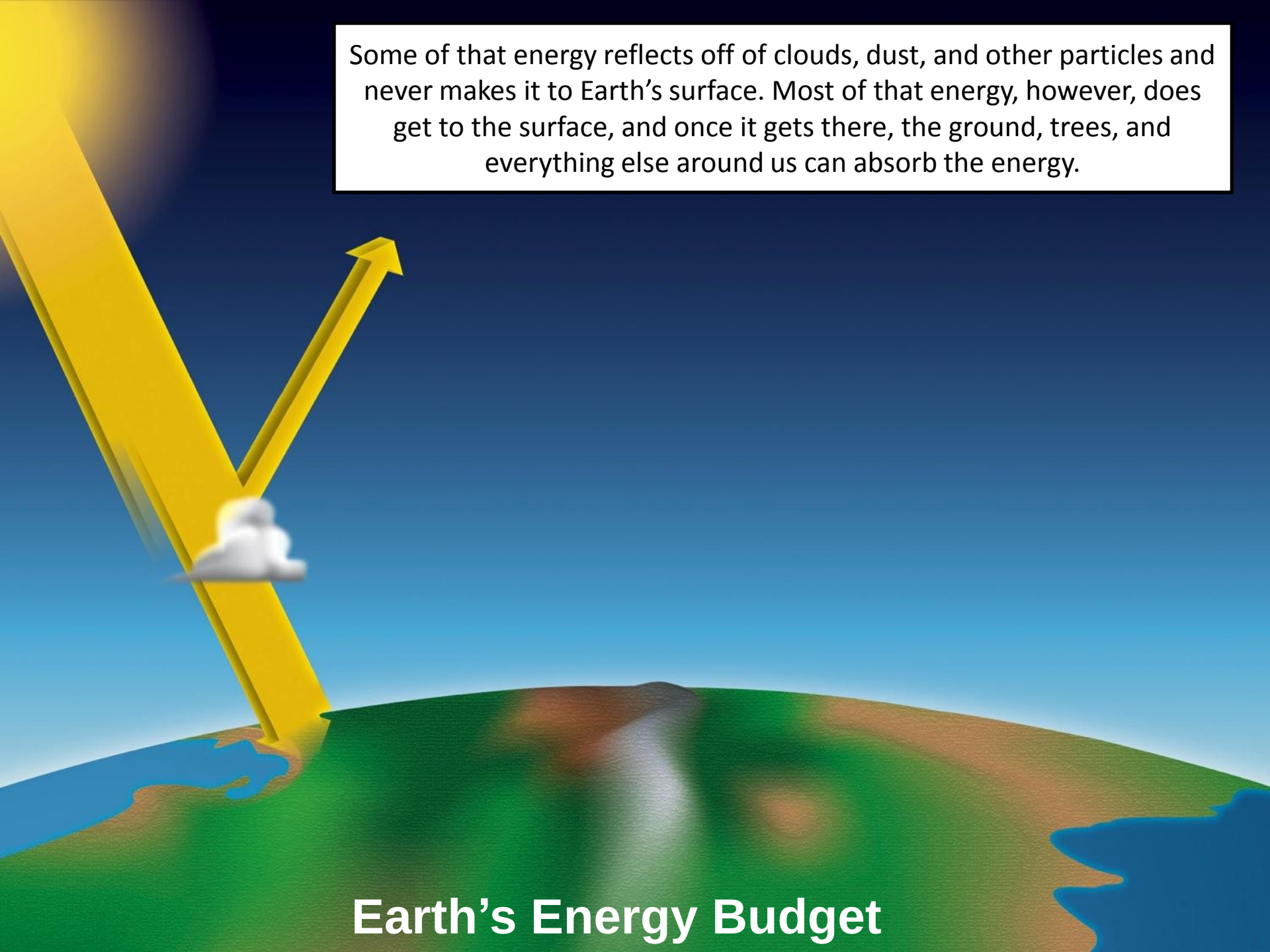
Average Surface Temperature
15 C (~59F)

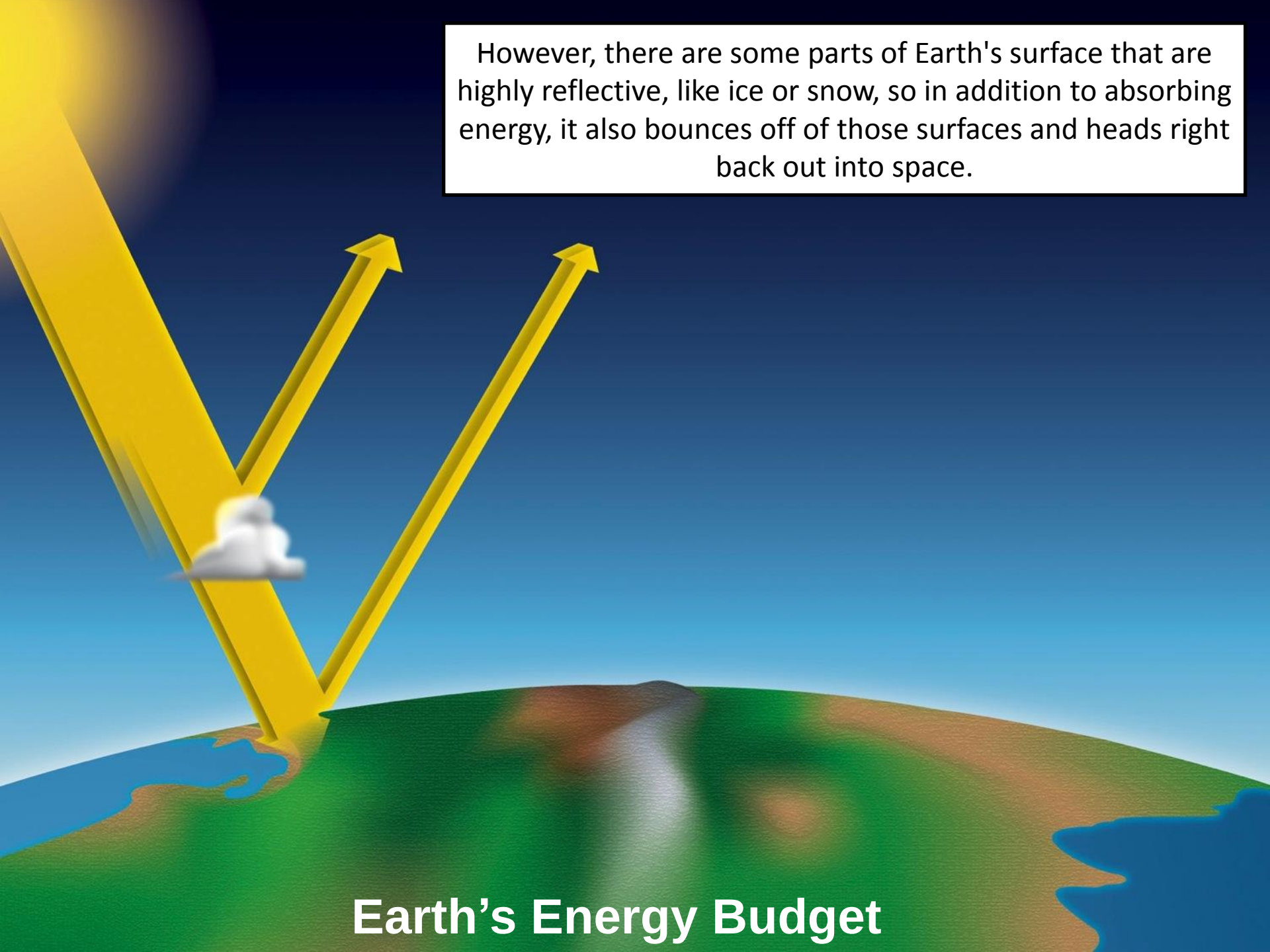


The temperatures of Earth and all the planets are determined by their "Energy Budget."



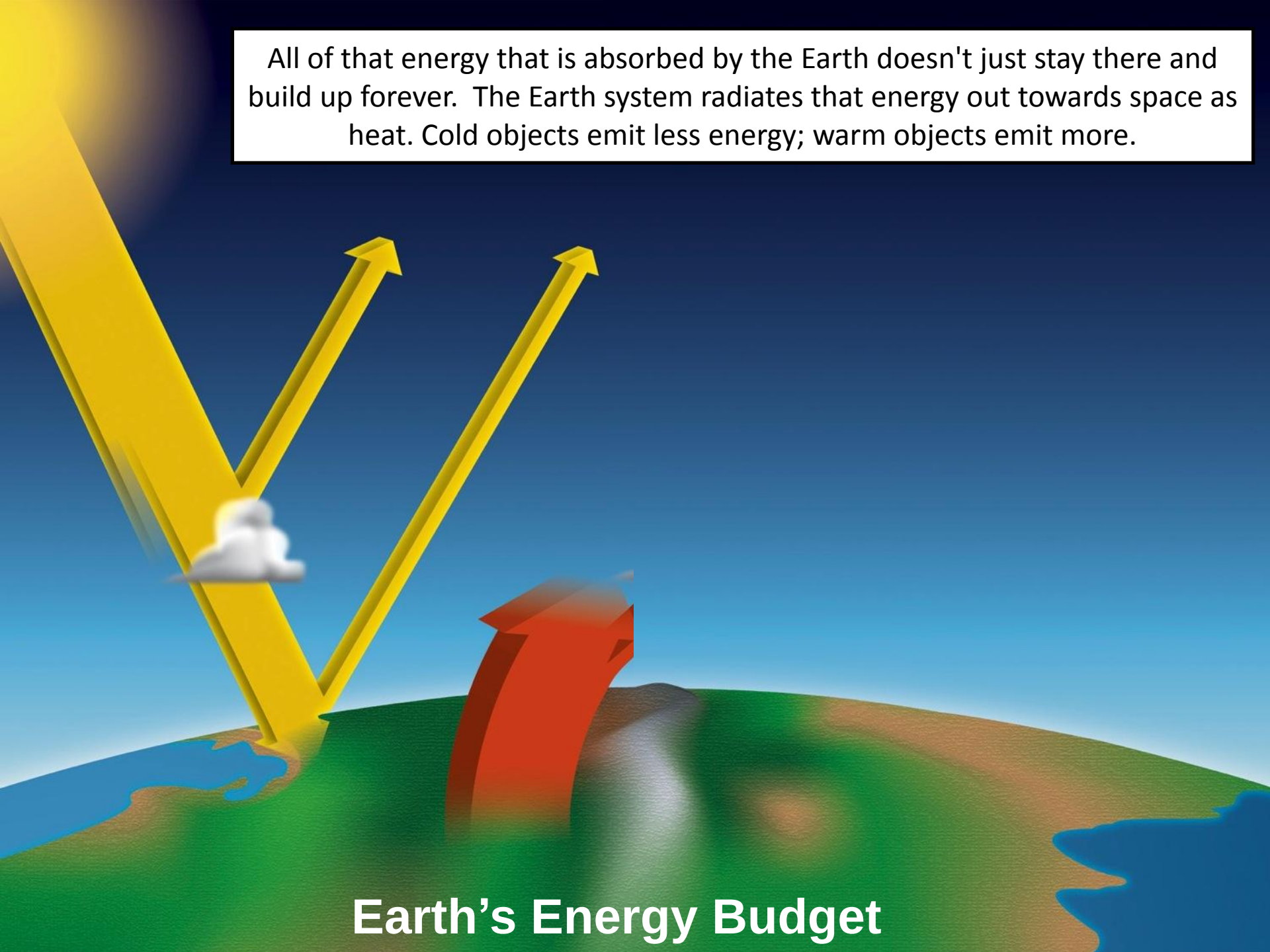
Earth’s Energy Budget


Some of that energy reflects off of clouds, dust, and other particles and never makes it to Earth's surface. Most of that energy, however, does get to the surface, and once it gets there, the ground, trees, and everything else around us can absorb the energy.
Earth's Energy Budget

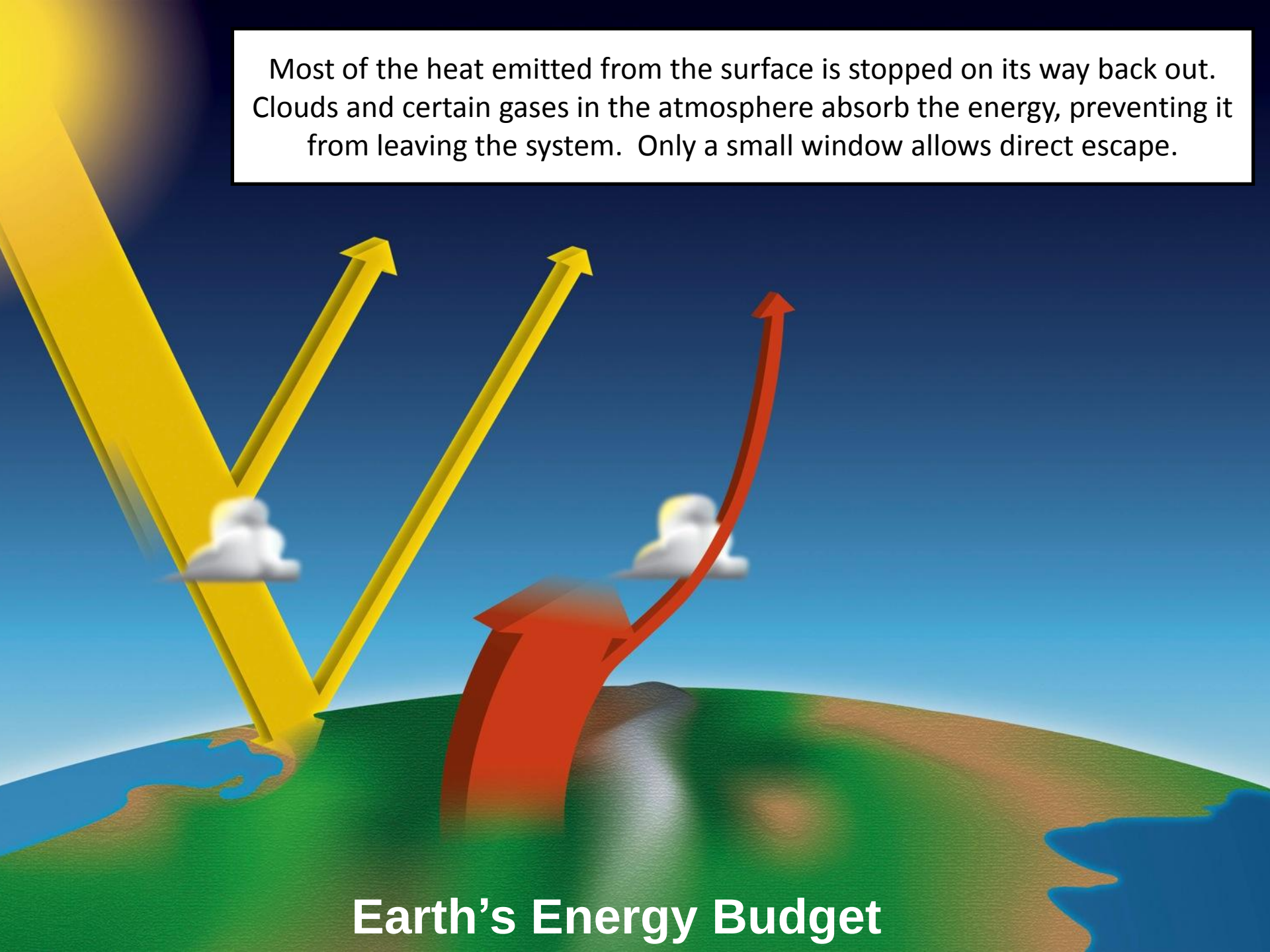


Earth’s Energy Budget

All of that energy that is absorbed by the Earth doesn't just stay there and build up forever. The Earth system radiates that energy out towards space as heat. Cold objects emit less energy; warm objects emit more.



Earth's Energy Budget


Most of the heat emitted from the surface is stopped on its way back out. Clouds and certain gases in the atmosphere absorb the energy, preventing it from leaving the system. Only a small window allows direct escape.
Earth's Energy Budget

Energy emitted from those clouds and gases goes in all directions. Some comes back to further warm the Earth. This is the greenhouse effect.

Earth's Energy Budget

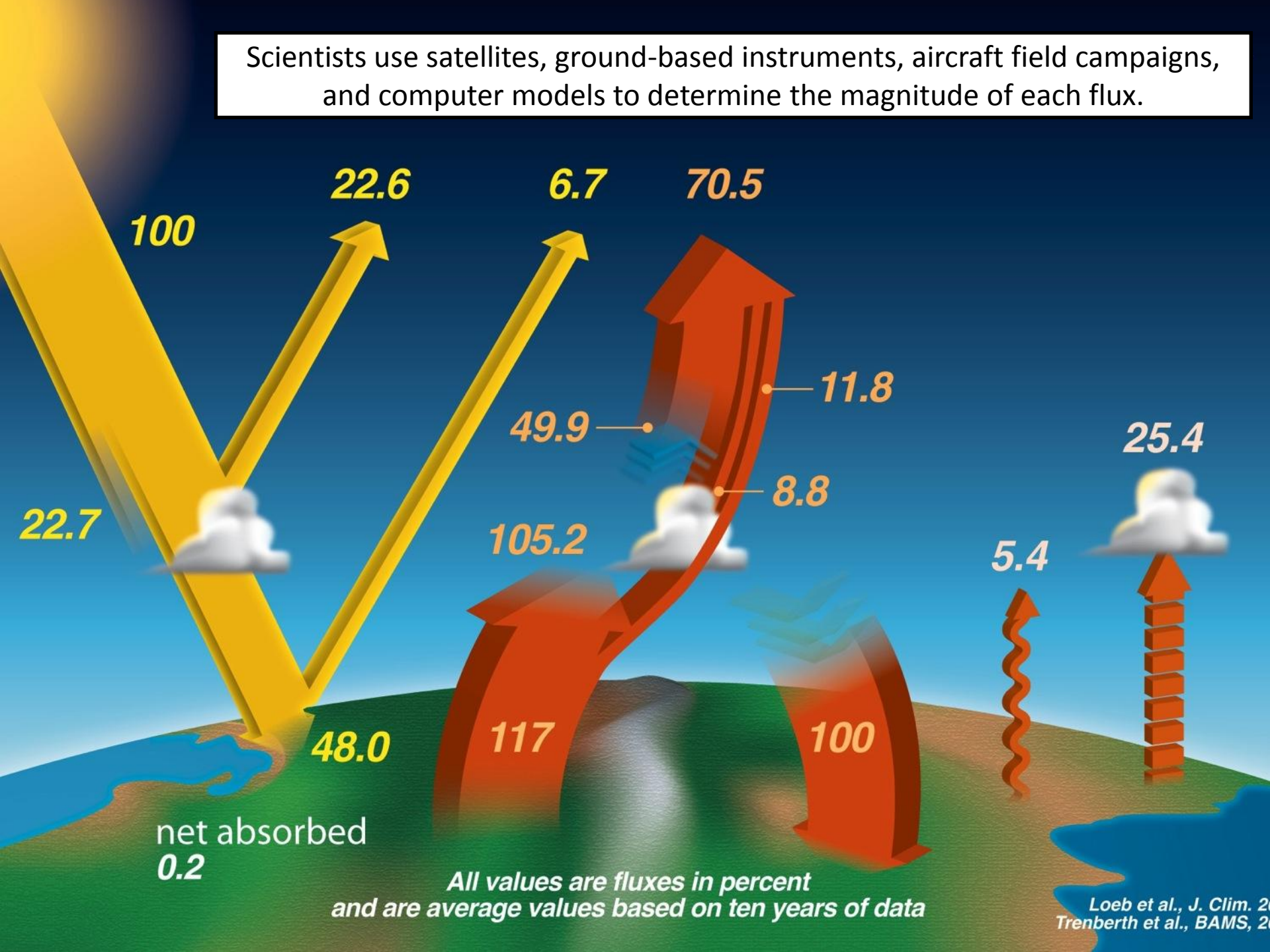
Finally, the surface energy budget is balanced by thermals and evaporation.

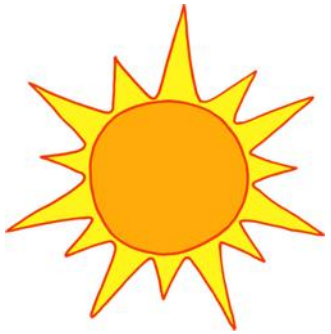
Earth’s Energy Budget

Together all of these forms of incoming and outgoing energy have resulted in just the right living conditions for us on Earth.

Earth's Energy Budget

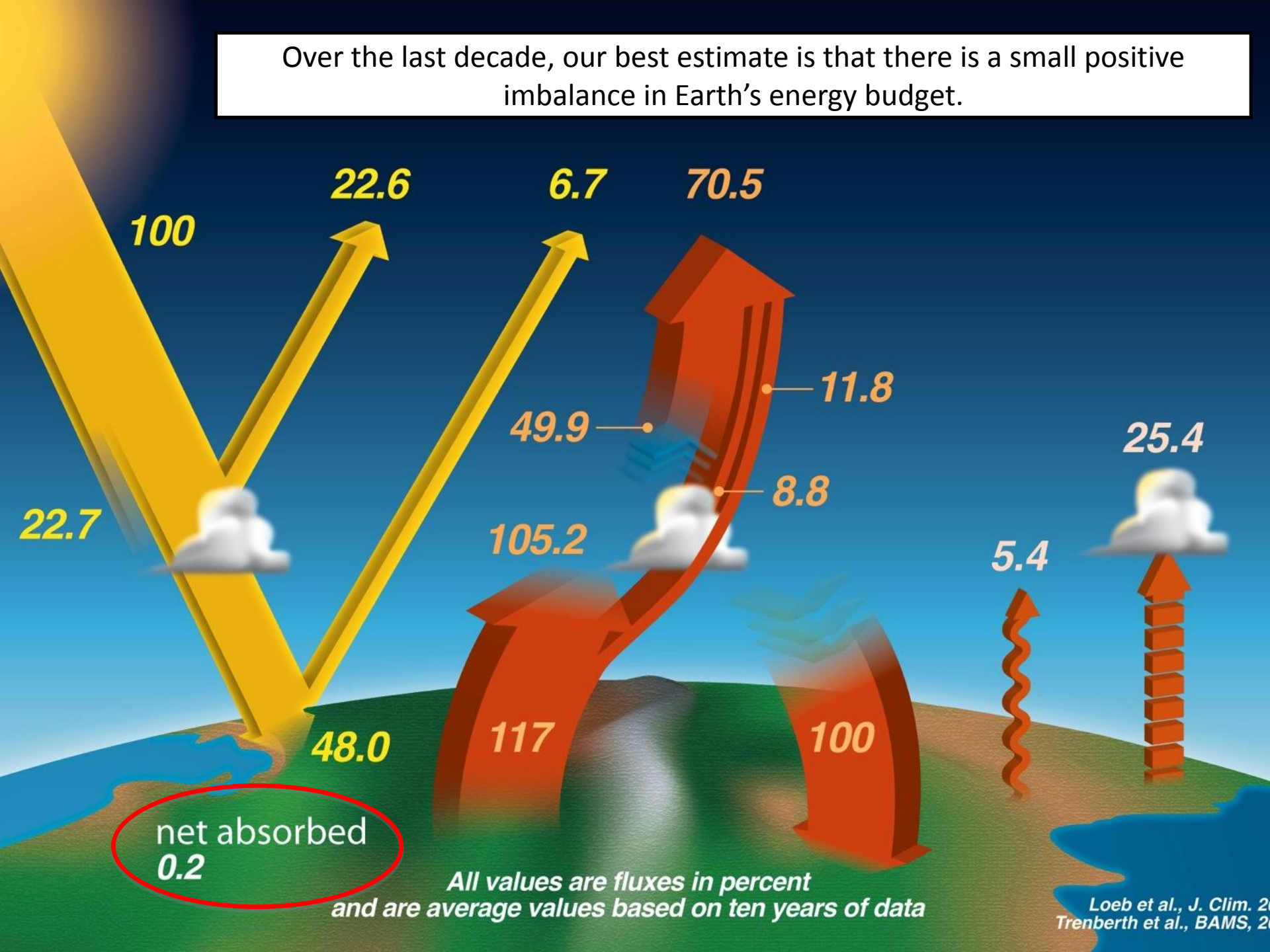
Scientists use satellites, ground-based instruments, aircraft field campaigns, and computer models to determine the magnitude of each flux.



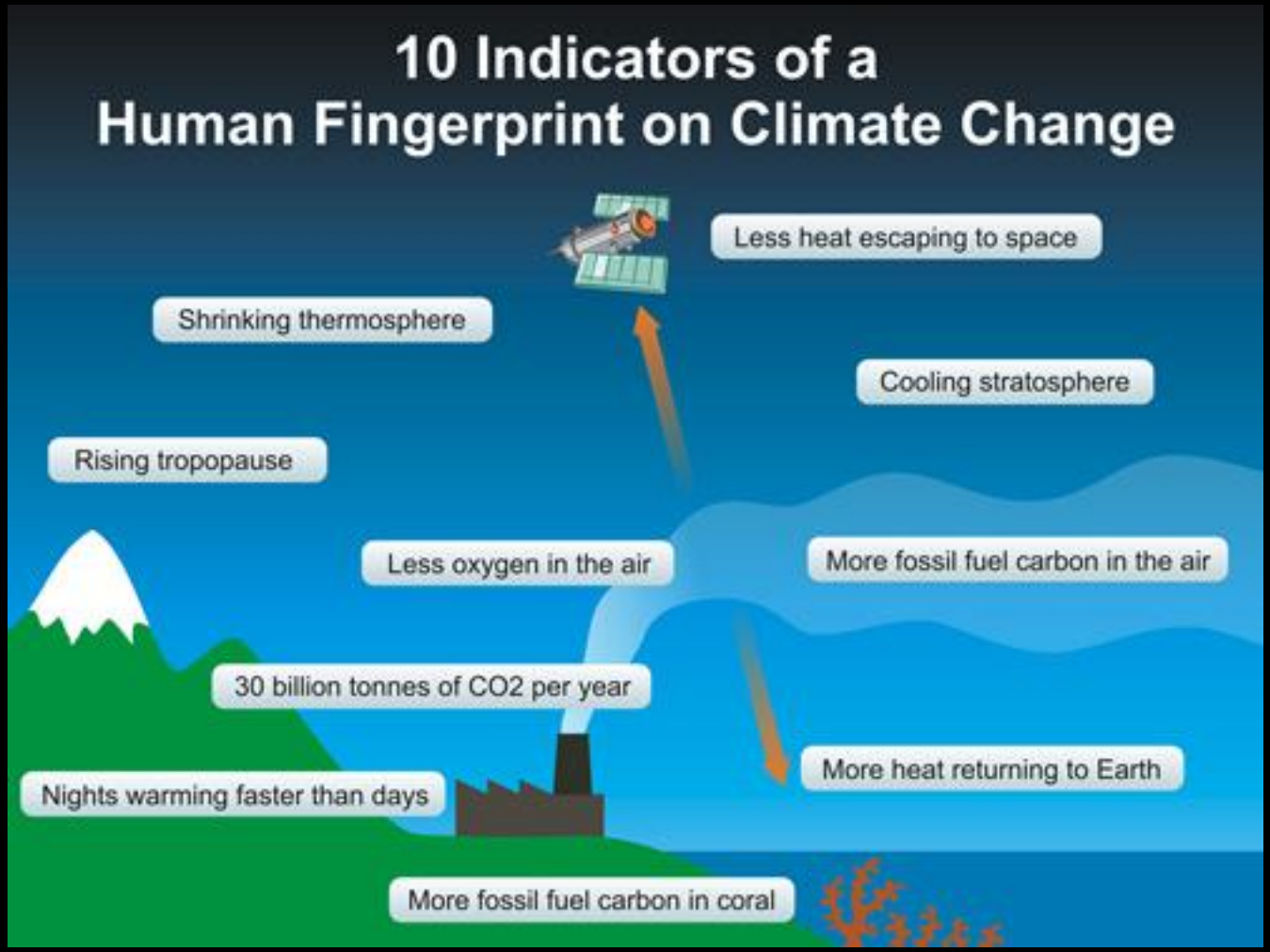


Like your house, anything that increases or decreases the amount of incoming or outgoing energy would disturb Earth's energy balance and would cause global temperatures to rise or fall.

Over the last decade, our best estimate is that there is a small positive imbalance in Earth's energy budget.



This is consistent with several other *lines of evidence* of a warming planet.



The End

… for now

Details behind the story

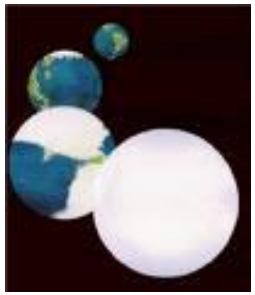
Balancing the Budget - I

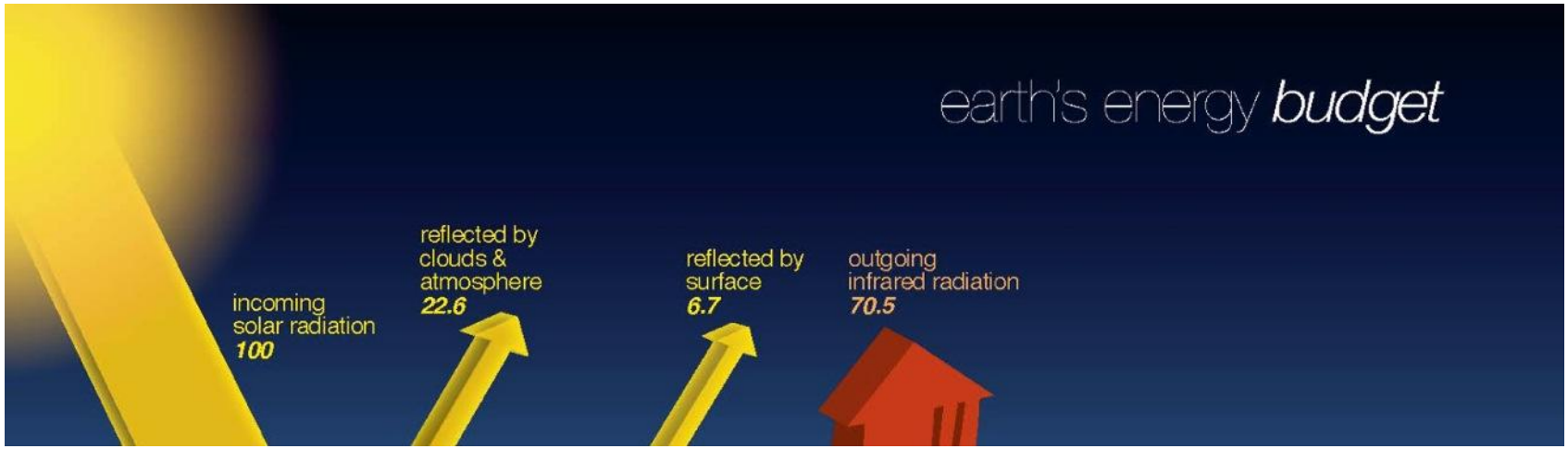
At the **top of the atmosphere**:

+ Sunlight In
– Sunlight reflected from clouds/atmosphere
– Sunlight reflected from surface
– IR emission

0?

Equilibrium Temperature: -18 °C





http://mynasadata.larc.nasa.gov/preview_lesson.php?&passid=44

Balancing the Budget - II

At the **Earth's surface**:

Equilibrium Temperature: 15 °C

+ Sunlight absorbed
– IR emission
+ IR back radiation (greenhouse effect)
– Thermals
– Evapotranspiration

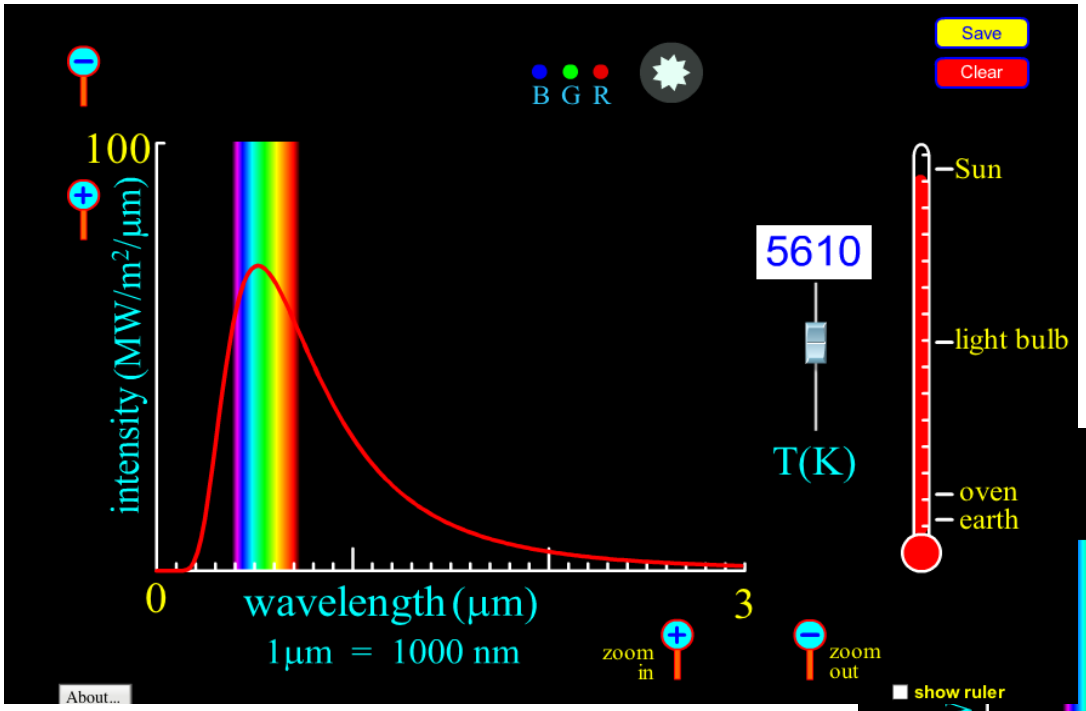
0?

http://mynasadata.larc.nasa.gov/preview_lesson.php?&passid=63
http://mynasadata.larc.nasa.gov/preview_lesson.php?&passid=67

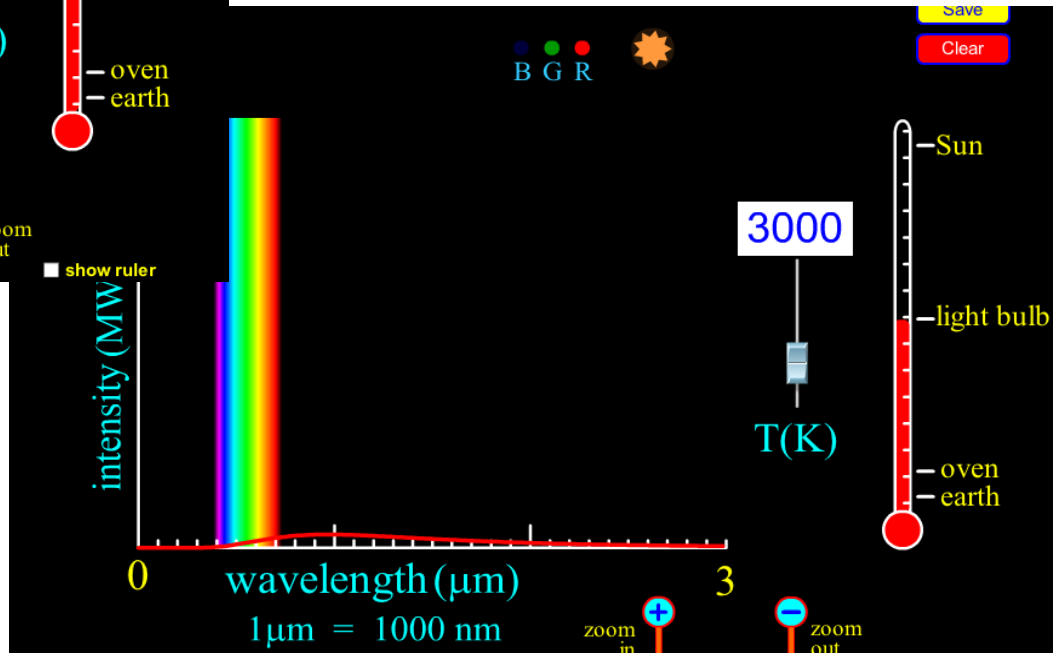
Greenhouse Effect

http://www.youtube.com/watch?v=b3NFfWlfj24

The Blackbody Spectrum

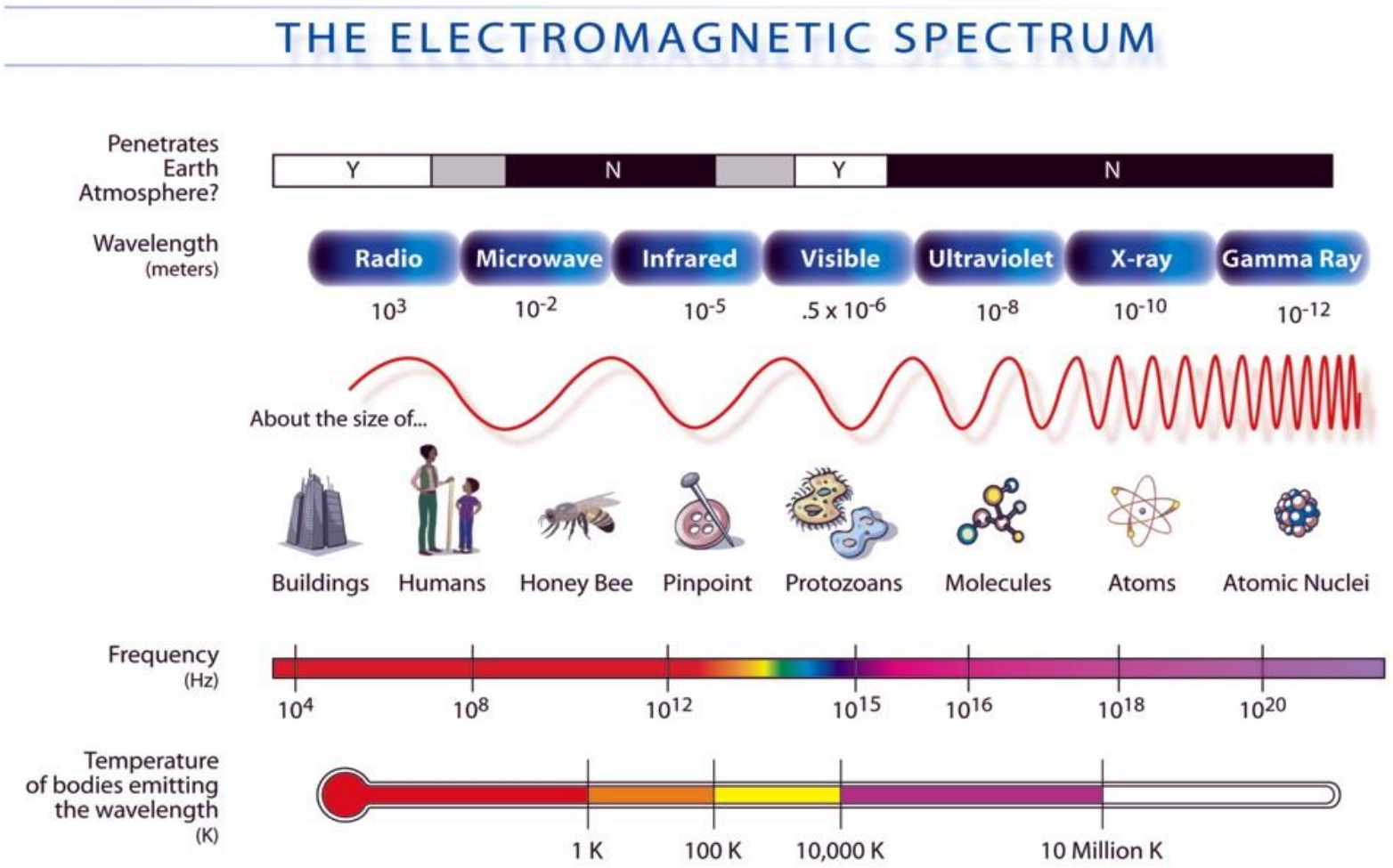


Every object emits energy according to its temperature. Hotter objects (like the Sun) emit lots of energy at mostly shorter wavelengths (visible); cooler objects (like the Earth) emit less energy at longer wavelengths (infrared).



http://phet.colorado.edu/simulations/sims.php?sim=Blackbody_Spectrum

The Electromagnetic Spectrum



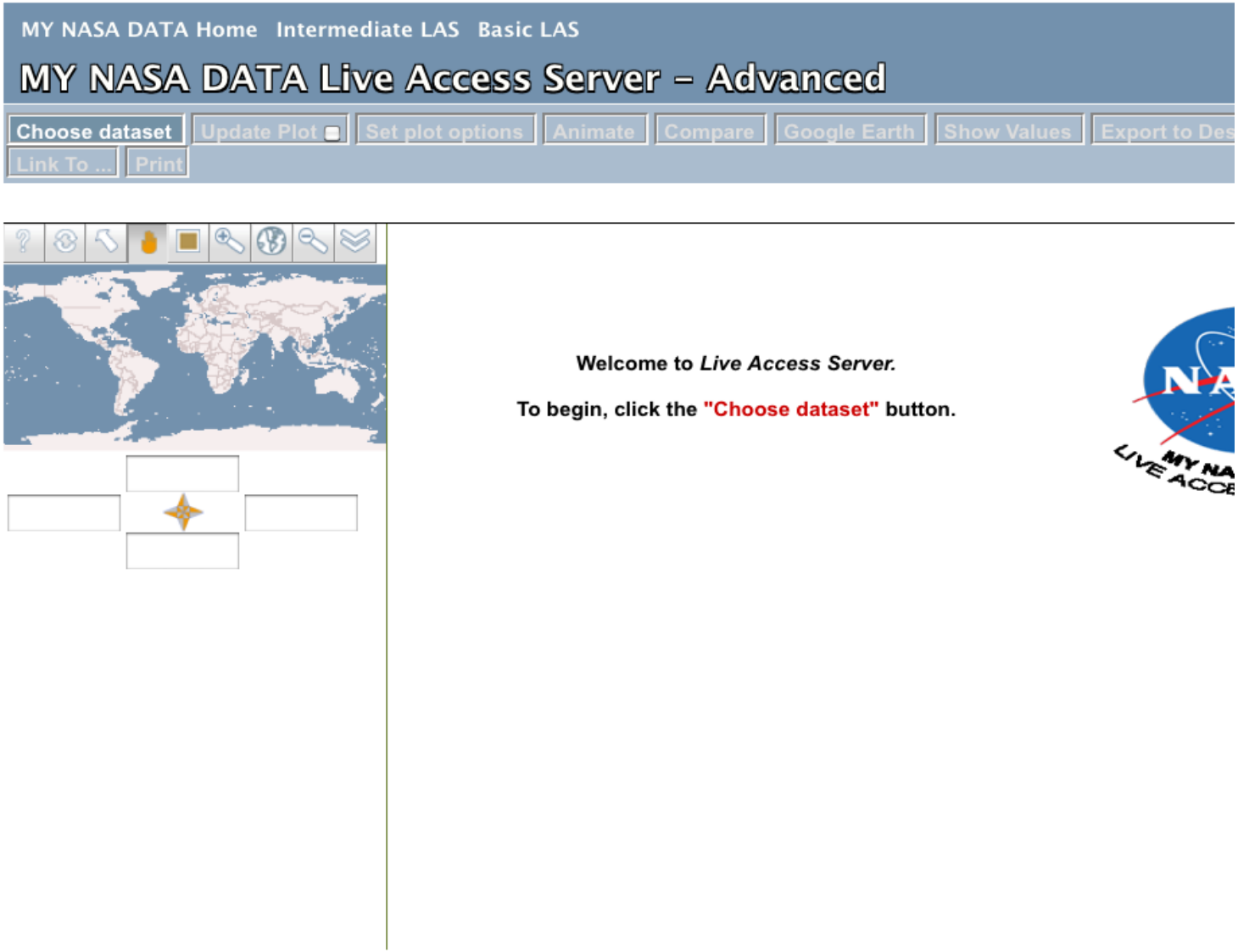
http://mynasadata.larc.nasa.gov/ElectroMag.html

Access to Data – MY NASA DATA

- Interactive access to energy budget data for classroom exploration
- Peer-reviewed lesson plans
- Science project ideas
- Science glossary

http://mynasadata.larc.nasa.gov/

Access to Data

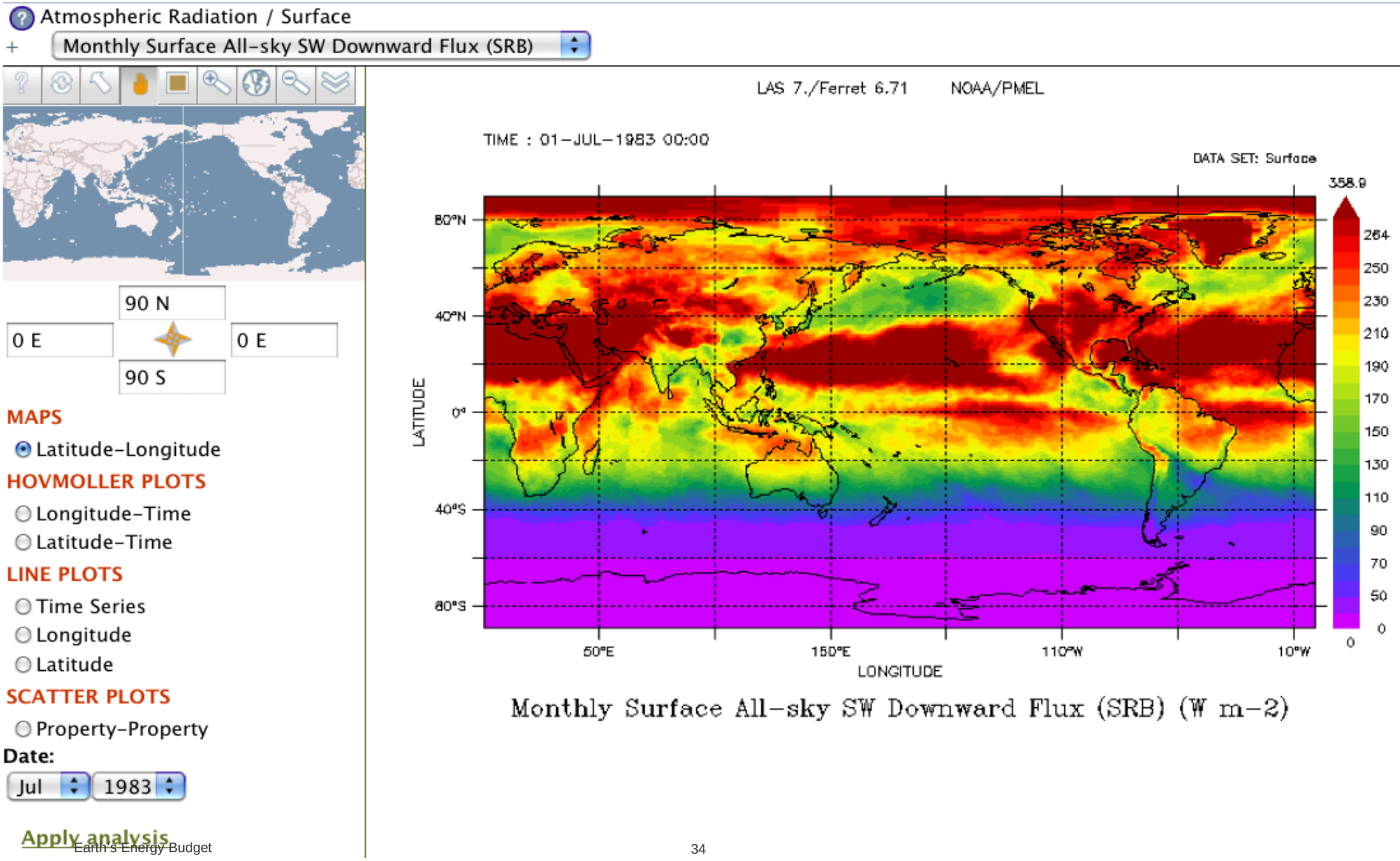


Access to Data

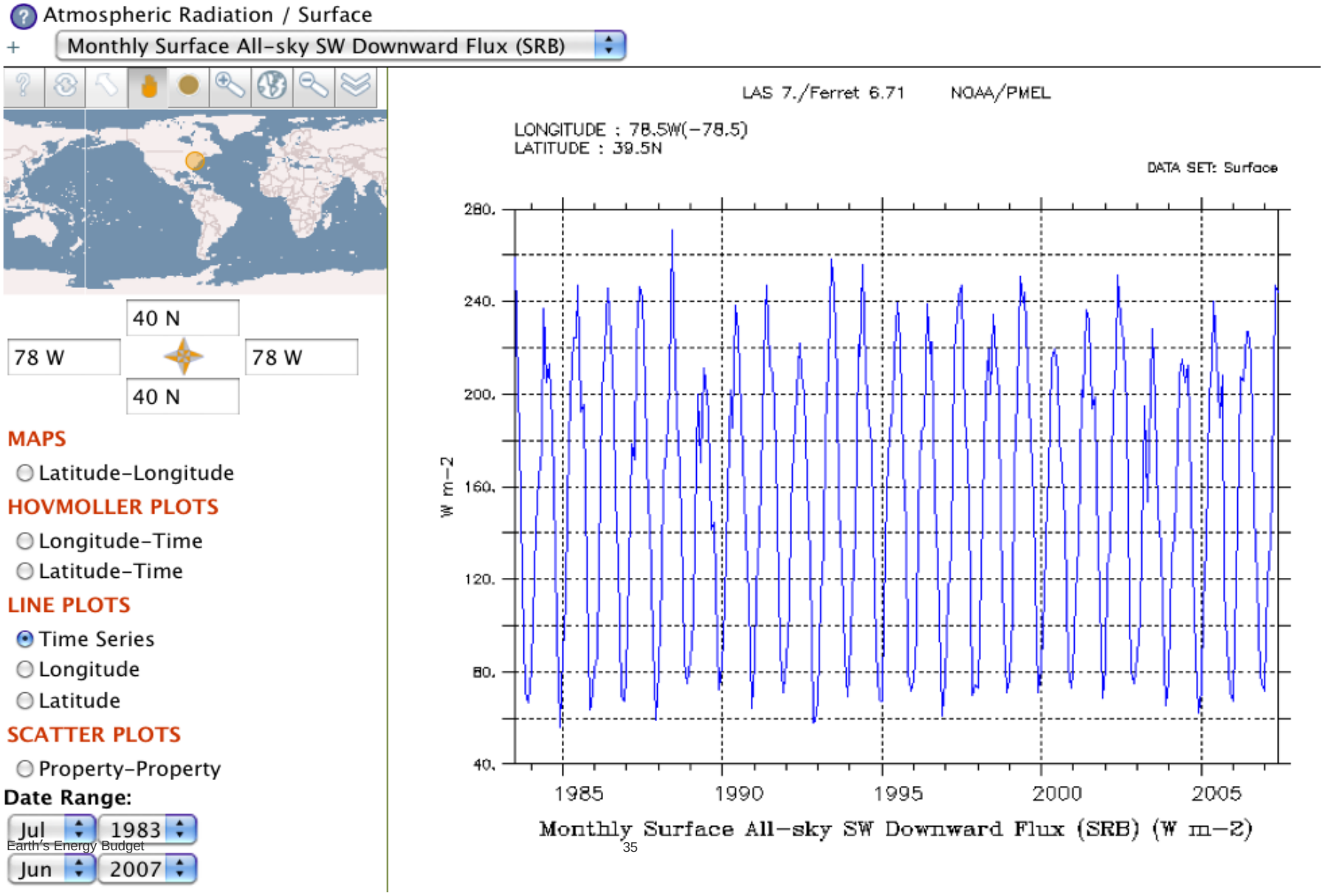
Datasets

- ⊞ Atmosphere
- ⊟ Atmospheric Radiation
  - ⊟ Surface
    - ○ Daily Surface All-sky LW Downward Flux (SRB)
    - ○ Daily Surface All-sky LW Upward Flux (SRB)
    - ○ Daily Surface All-sky SW Downward Flux (SRB)
    - ○ Daily Surface All-sky SW Upward Flux (SRB)
    - ○ Daily Surface Clear-sky SW Downward Flux (SRB)
    - ○ Daily Surface Clear-sky SW Upward Flux (SRB)
    - ○ Daily Surface Clear-sky LW Downward Flux (SRB)
    - ○ Daily Surface Clear-sky LW Upward Flux (SRB)
    - ○ Monthly Surface All-sky LW Upward Flux (SRB)
    - ○ Monthly Surface All-sky LW Downward Flux (SRB)
    - ○ Monthly Surface Clear-sky LW Upward Flux (SRB)
    - ○ Monthly Surface Clear-sky LW Downward Flux (SRB)
    - ○ Monthly Surface Clear-sky SW Downward Flux (SRB)
    - ○ Monthly Surface Clear-sky SW Upward Flux (SRB)
    - ○ Monthly Surface All-sky PAR Flux (SRB)
    - ◉ Monthly Surface All-sky SW Downward Flux (SRB)
    - ○ Monthly Surface All-sky SW Upward Flux (SRB)
  - ⊞ Top of Atmosphere (TOA) All Sky
  - ⊞ Top of Atmosphere (TOA) Clear Sky
- ⊞ Biosphere
- ⊞ Cryosphere

Access to Data



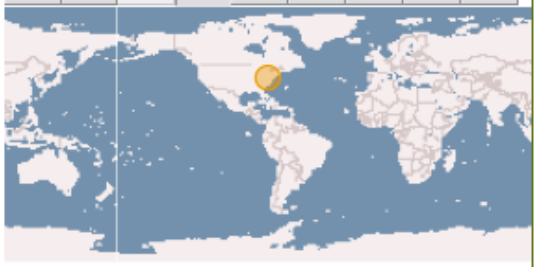
Access to Data



Access to Data

Atmospheric Radiation / Surface

Monthly Surface All-sky SW Downward Flux (SRB)



40 N

78 W 78 W

40 N

MAPS

- Latitude-Longitude

HOVMOLLER PLOTS

- Longitude-Time
- Latitude-Time

LINE PLOTS

- Time Series
- Longitude
- Latitude

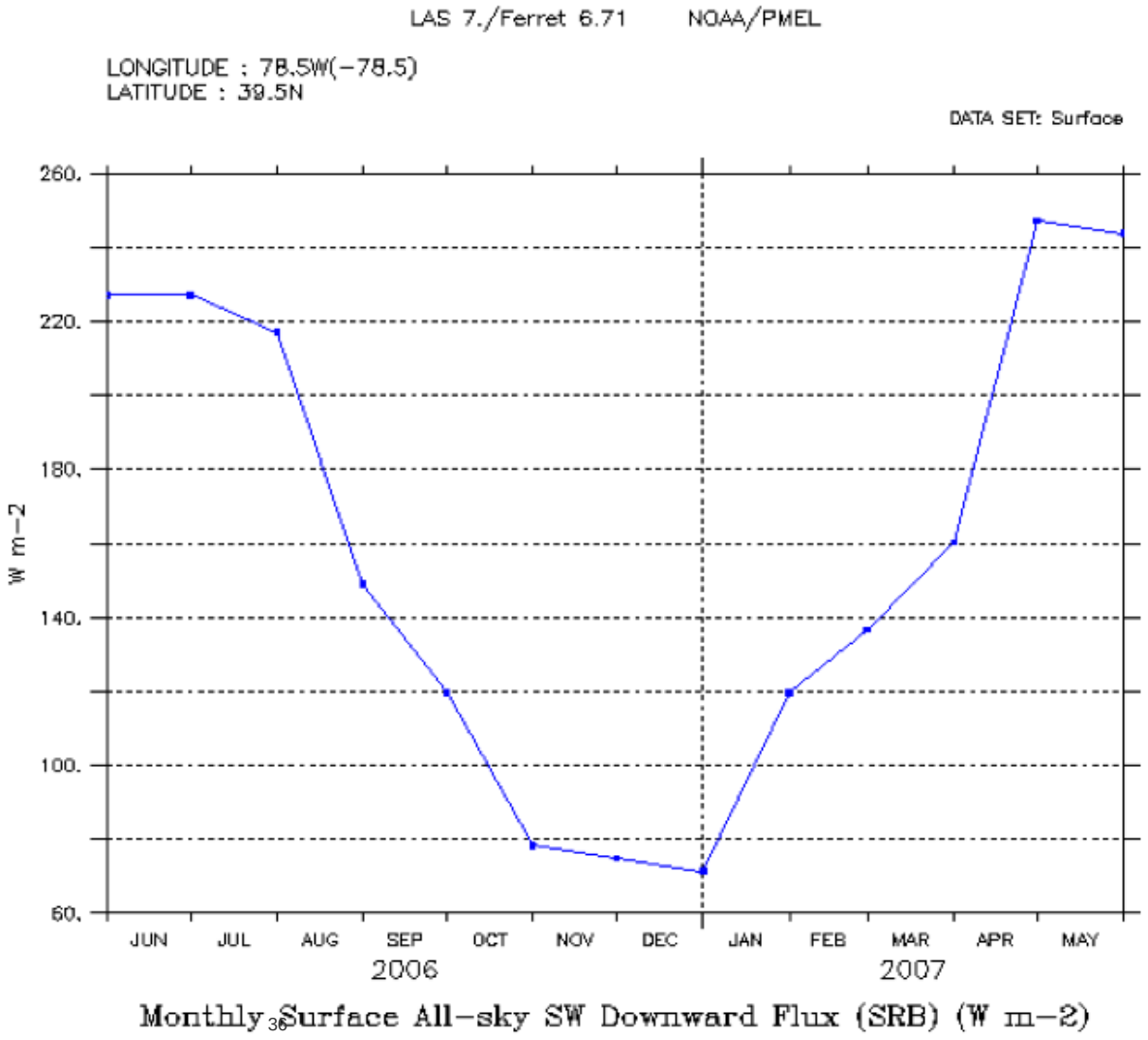
SCATTER PLOTS

- Property-Property

Date Range:

Jun 2006

Jun 2007



Access to Data